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ABSTRACT

Seven paired-associates were constructed using words (for which scales values on arousal were derived by paired-comparison technique) as stimulus terms and digits (two through eight) as response terms. Forty subjects were randomly assigned to one of four conditions-cued or free recall and short or long-term tests following a single learning trial. Recall of pairs was very poor in all conditions. That level of arousal of words aids in the learning of the pairs was not substantiated by an analysis of the free-recall data on recall of the pairs, the stimulus terms, and the response terms. (Author)

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The Relationship of Arousal to Retention of Stimulus-Response, Response and Stimulus Terms in Paired Associate Learning

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Seven paired-associates were constructed using words (for which scales values on arousal were derived by paired-comparison technique) as stimulus terms and digits (two through eight) as response terms. Forty subjects were randomly assigned to one of four conditions--cued or free recall and short or long term tests following a single learning trial. Recall of pairs was very poor in all conditions. That level of arousal of words aids in the learning of the pairs was not substantiated by an analysis of the free recall data on recall of the pairs, the stimulus terms and the response terms.

In studies relating arousal to retention, researchers have generally used a single trial paired-associate (PA) learning task followed by a cued recall test in which the stimulus (S) term was provided and the S was to recall the associated response (R) term (for example, Kleinsmith and Kaplan, 1963, 1964; Kumar and Farley, 1971; Osborne, 1972; and Walker and Tarte, 1963). In all these studies S terms (words or trigrams were paired with R terms (digits). Except in the case of Kumar and Farley (1971), arousal was always considered in terms of the S term. For example, Kleinsmith and Kaplan (1963) defined arousal as any drop in skin resistance that occurred within 4 seconds of presentation of a given word. The same technique was used by Kleinsmith and Kaplan (1964), and Walker and Tarte (1964), Osborne (1972) used low and high arousal words based on *a priori* judgement. These studies have used the one-trial incidental learning paradigm. Inherent in these studies is an assumption that arousal due to the S term is more important than arousal due to the R term for the learning of the R term, or, that arousal due to S aids the learning of the R term. In terms of memorial processes, it seems the assumption is that there is a generalization of arousal from the S word to the learning of the S-R pair.

It seems reasonable to question these assumptions, since in all the above studies, the recall of the R terms has been extremely poor. For instance, Kleinsmith and Kaplan (1963) found that the immediate recall of numbers associated with low arousal words was five times better than numbers associated with high arousal words. However, examining their data more closely, it could be noted that recall of numbers paired with low arousal words was less than 50 percent of the total possible recall. Similar was

the case for high arousal words for the long-term retention (LTR condition. Walker and Tarte (1963) findings indicated even poorer recall falling below 40 percent of the possible total. Among the more recent studies Kumar and Farley (1971) reported a range of recall from 8.33 percent to a maximum of 27.08 percent for the five treatment conditions. Osborne (1972) obtained less than 30 percent recall of the response digits for his one trial learning condition.

The conclusion from the above studies is obvious - regardless of the arousal properties of the S term, the recall of the R term is poor. This is of theoretical interest, since one could argue that although S and R are shown together to the subject, more than likely the consolidation of the S and R terms might go on independently rather than as an S-R unit. If S-R pair is processed as a unit, we can expect no differences between free recall of S-R pairs and a cued recall of the R terms given the S term. However, if cued recall yields higher retention score than the free recall score, then we can possibly say that although S-R pair may be processed as a unit, its strength is weak. A further confirmation can be obtained by comparing the free recall of S, R, and S-R terms. If the S-R pair is not processed as a unit, or that there is little or no generalization of arousal from the S term to the learning of the S-R as a unit, then we may expect a higher recall of the S and the R terms as compared to the recall of the S-R pairs in a free recall test following the learning trial. One might also note that in the studies cited above, the S term was shown first, followed by the S-R pair in the learning trial. If repetition of the S term causes greater neural reverberation and prolongs the time for the consolidation of the memory trace (Walker, 1958), we should

expect low short-term retention (STR) of S terms as compared to LTR of S terms in general and the reverse for the R terms (digits) if one can assume the digits to have low arousal properties (especially if S terms are words rather than trigrams). Thus, the major question of interest to this study was to obtain evidence for the notion that S terms and R terms are more than likely processed independently rather than as a pair (in a single trial PA task) regardless of the arousal properties of the S term. Another question of interest was to relate arousal values of S terms [obtained from another experiment (done simultaneously with the current one and Ss were randomly assigned to the two experiments) using the paired comparison method of scale construction] to the retention of S-R pairs in a cued recall condition and the free recall of S, R and the S-R pairs. It may be noted that the two questions stated above are not entirely mutually exclusive.

Method

Subjects. Ss were 80 paid ($2.00) from several undergraduate courses in education. Forty Ss were randomly assigned to the experiment for the determination of scale values, and the other 40 Ss were randomly assigned to the present experiment.

Learning Materials - Seven words were chosen from the category of unpleasant words used by McNulty and Isnor (1967). These words were FAMINE, PLAGUE, HATRED, MISERY, DEADLY, TRAGIC, and COWARD. The procedure for deriving the scale values using the paired comparison method are described in detail in Powers (1973). For the present study, the seven words were paired with digits 2 through 8 respectively.

The PAS were presented on 2-inch square slides using Kodak Ektagraph

projector. To separate the arousal effects of one set of pairs from the next, two color slides having five different color circles were presented between the word-digits slides (as in Kleinsmith and Kaplan, 1963 and other studies). Slides were projected from outside a sound proof booth and communication between the S and the E was carried out by an intercom.

Procedure - Ss were randomly assigned to one of four conditions: (a) cued STR, (b) cued LTR, (c) free recall STR, and (d) free recall LTR. Thus, each condition contained 10 Ss. Ss were told that the major purpose of the experiment was to record heart rate (HR) while they performed a task, (although no measurements were really taken two electrodes were applied to the chest surface). For use in all conditions, ten different training lists were carefully generated to avoid any serial effects. The ordering of the first stimulus being paired with "2", the second with "3" and so on, were eliminated. The inverse ordering of this series was also dropped. Ss were randomly assigned to different recall lists. After the Ss were seated comfortably on a padded chair located in the booth, they received the following instructions:

> "You will be shown three types of slides; concentrate on them carefully. They will appear briefly. One type of slide shows five circles, arragned horizontally in two rows of two circles on the top row and three circles on the bottom row. When these slides appear, you are to say the colors aloud in any order that you wish. A second type of slide shows a single word. When these slides appear, you are to say the word aloud. A third type of slide shows a word and a number. When these slides appear, you are to say aloud the word and the number. I will remain outside. Are there any questions?"

Learning Phase and Testing Phase for Each Condition - The learning phase for PA task for both STR and LTR involved the presentation of the stimulus items alone for 5 seconds followed by the presentation of the stimulus and response item together for 5 seconds. Ss assigned to STR were tested within 10 seconds following the presentation of the last color slide. During the recall session stimulus words alone were presented for 5 seconds each and the Ss were instructed to recall the correct number and to guess if uncertain. The correct numbers were not repeated. Color slides were used as before as an interpolated task., Ss communicated their responses through the intercom and E recorded the responses.

Ss for cued LTR received a similar learning trial but were requested to return at the same time the following day for further HR recordings and at that time were tested for recall. The learning phase for Ss in the free recall conditions remained the same as that described for cued conditions. The testing phase, however, changed. Ss in the STR condition were tested for recall 10 seconds after the presentation of the last color slide. Similarly, Ss in the LTR condition were tested at the same time on the following day. The same concern with HR measurement was expressed to the LTR Ss. For the actual testing phase, Ss for both STR and LTR were asked to freely recall stimulus and response items without viewing the stimulus word. Ss were instructed to recall and say aloud the word-number combinations from the slides they viewed, or if they could not remember the words and numbers in combinations but could recall individual words or numbers, say those aloud. There was no response time limit; Ss indicated when they could not recall further items.

Results

Is S-R pair processed as a unit? An analysis of variance on data from

the recall in cued conditions and the free recall conditions indicated that S-R pairs were recalled equally for both conditions, $F(1,36) = 2.17$ $p > .05$. There was significant lowering of retention from STR to LTR, $F(1,36) = 7.47$, $p < .01$. The interaction between retention interval and recall condition (cued or free) was not significant $F(1,36) < 1$. On the surface, these results indicate that S-R pairs are processed as a unit. However, like in previous studies, the PAS were very poorly recalled in all the conditions. (See Table 1)

Table 1

The means ranged from 4.3 percent to 18.6 percent of the total number of words presented to each S. Considering that the average recall was so poor, it seems reasonable to say that consolidation of a pair is a very difficult task following one learning trial. A possibility was mentioned in the introduction that S and R terms are processed independently rather than as a pair. The free recall data on the recall of the S-R, R and S terms (for both STR and LTR tests) was subjected to a between - by - within subjects analysis of variance. For this analysis S-R, R and S terms were mutually exclusive categories. Analysis showed no significant difference due to retention interval $F(1,18) = 3.47$, $p > .05$. The main effect of Recall terms (differences between S-R, R and S terms) was significant $F(2,36) = 18.37$, $p < .01$.

Since the main effect of Recall of Terms was significant, a post-hoc analysis was performed, using Scheffe's procedure (Kirk, 1968). Table 2 presents the means for various conditions.

Table 2

Table 3 reports the results from the post-hoc analysis of the means.

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Table 3

It is clear from Table 2 and 3 that S Terms were recalled best, followed by the response digits, followed by the S-R pairs, lending support to the notion that S and R terms are more than likely processed independently.

It was indicated earlier that S terms were repeated twice and R term was shown only once during the learning trial. It was hypothesized that if repetition of S term causes greater neural reverberation when compared to R and if it can be assumed that in general S terms are more arousing than R digits, then the action decrement theory would predict a significant interaction between Recall terms and Retention interval. This was not borne out, the interaction was not significant $F(2,36) = 1.84$, $p > .05$.

Relationship of arousal to retention. Correlations were computed between scale values derived using the paired comparison and retention of various terms (S, R and the S-R pairs) in various conditions. The only respectable correlation was for the stimulus words ($r = -.5994$) in the free recall STR condition, i.e., the scale values accounted for almost 36 percent variance in the free recall of S terms. It may be noted a negative correlation would be predicted by the action decrement theory. The other correlations were extremely low. (See Table 4.)

Table 4

To get a better picture of what was happening, frequency of recall of various terms were plotted against their respective scale values (see

Figures 2 through 5). Pattern of relationships were not consistent for the various terms in different conditions, and there was no clear cut support for the action decrement theory. It was clear, however, that S-R pairs were recalled poorly regardless of the arousal values of the S terms.

Further analysis was done on the proportion of responses recalled in the cued recall condition and the proportion of S-R pairs recalled in the free recall conditions, taking into consideration the levels of arousal of words grouped into high (H), medium (M), and low (L) categories (see Figure 1). This analysis revealed a significant lowering of retention from STR to LTR, $F(1,36) = 6.91$ $p < .01$. There was no difference in the recall of S-R pairs between the cued and the free recall condition, $F(1,36) = 1.31$ $p > .05$. There were no differences due to the level of arousal of words, $F(2,72) < 1$. None of the interactions were found to be significant.

Finally, analysis of variance was performed on the free recall data of S-R, R and S terms. Data were transformed into proportion of correct recall for H, M, L categories before the analysis was performed. The interesting outcome of this analysis was a significant difference between the S-R, R and the S terms (recall terms), $F(2,36) = 15.04$ $p < .01$ (using both conventional and the conservative Geisser-Greenhouse test). The interaction between retention interval (STR-LTR) and recall terms was significant $F(2,36) = 16.21$, $p < .01$. An examination of the mean proportions suggested that R terms were recalled equally for both STR and LTR conditions, but there seemed to be a depression for the S-R and the S terms from STR to LTR (see Figure 6). Another significant interaction was that between level of arousal of Recall terms $F(4,72) = 3.22$ $p < .05$. The test was not

significant using the conservative test and hence the correction factor suggested by Myers (1972) was used, $F(2,45) = 3.22$ $p < .05$. An examination of the mean proportions suggested that although at all levels of arousal S terms were recalled better than the S-R pairs, the difference tends to be smaller at H than at L and M levels of arousal (see Figure 7).

Finally, the three-way interaction between recall interval, arousal and Recall terms was significant using both the conventional and the conservative test $F(4,72)$ or $F(1,18) = 4.70$ $p < .05$. Further analysis indicated that the average difference between STR and LTR for S-R, R and S terms for M arousal words was greater than the average differences between STR and LTR for L and H words. The interaction is presented in Figure 8. Recall of S-R pairs appears to be poor for M arousal words, while the opposite appears to be the case for R digits. The S terms were recalled better at all levels of arousal on STR as compared to LTR test, but the differences tend to get smaller with an increase in the level of arousal. This inconsistency in the trends of recall patterns can again be considered to favor the notion that regardless of arousal, S and R terms are more than likely processed independently (or set up their own independent traces) rather than as a unit.

Discussion

The different analyses did support the notion that although S and R terms are shown together, they are more than likely processed independently rather than as a unit (or the S and R terms set up their independent traces). It was seen that S and R terms were recalled better than the S-R pairs in the free recall conditions regardless of the arousal properties of the S terms. A floor effect for the recall of the R digits in the cued recall condition was consistent with the results of several studies mentioned in

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the introduction section. In the present study, it seems fair to say that the Ss were more than likely operating on chance or merely guessing the S-R association in both the cued and the recall conditions. That this suspicion is not entirely reasonable can be judged from the fact that the mean recall ranged from 0.30 to 1.30 (Table 1) in various conditions. It may be noted that S terms and R terms were recalled significantly better than the S-R pairs. This again indicates that Ss were storing the S and R terms independently of each other and not as a pair.

A question of interest here is to account for the superior recall of the S words when compared to the R digits. One possibility was that there was a repetition effect i.e., since S words were presented twice and R terms only once during the learning trial. A second plausible explanation is that S and R terms have differential arousal properties, but that there was no significant interaction between retention interval and recall terms rules out this possiblity. A third possibility is that the reverberation due to the S word (being shown first and twice) interferes with the reverberation of the R digits and produces some kind of a proactive interference effect or perhaps an anterograde amnesic effect. Finally S words may simply be easier to consolidate than the R digits or that S words are more meaningful than R terms and forming the pairs may be the least meaningful task to the S.

With respect to the relationship of arousal to retention of various terms in various conditions, it may be concluded that there was no clear support for prediction derivable from the action decrement theory (Walker, 1958), nor were the results clearly interpretable.

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Table 1

Mean Recall for Retention of S-R Pairs

	Cued Recall	Free Recall	Combined Mean
STR	1.30	1.0	1.25
LTR	0.70	0.30	0.50
Combined Mean	1.0	0.65	. . .

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Table 2

Mean Number of Responses under Different Retention Intervals and Types of Recall

	S-R	R	S	Combined Mean
STR	1.0	1.5	3.3	1.93
LTR	0.3	1.7	2.2	1.4
Combined Mean	0.65	1.6	2.75	. . .

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Table 3

Summary of *Post Hoc* Analysis of Recall of S-R, R, and S Terms

Contrast	Confidence Interval (p=.05) ($\hat{\beta}_j - \hat{\beta}_{j'} \pm$ SSE $\hat{\beta}_j - \hat{\beta}_{j'}$)
$\hat{\beta}_{S\text{-}R} - \hat{\beta}_R$	-0.95 ± 0.8936*
$\hat{\beta}_{S\text{-}R} - \hat{\beta}_S$	-2.10 ± 0.8936*
$\hat{\beta}_R - \hat{\beta}_S$	-1.15 ± 0.8936*

*significant.

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Table 4

Correlation Coefficients for Scale Values and Frequency of Recall in Various Conditions

	STR	LTR	
Cued Recall	-.1623	0.2745	
Free Recall			
S - R	0.0326	0.2572	
S	-0.5994	0.1616	
R	-.1167	0.2982	

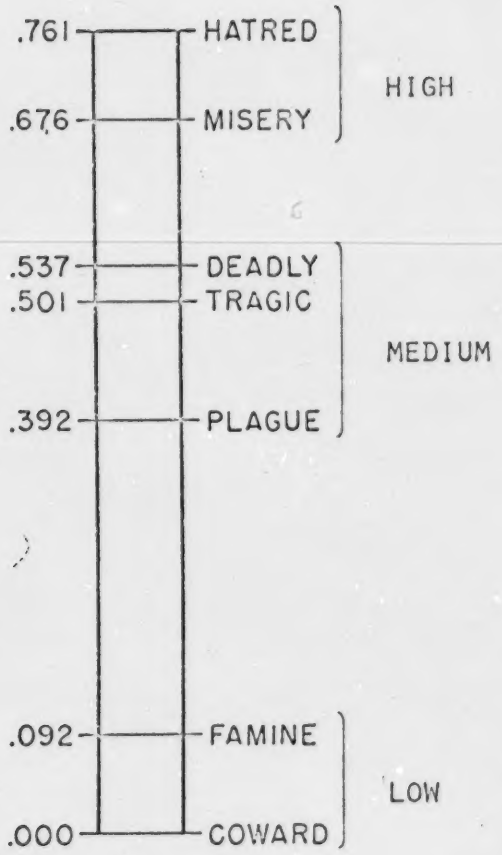

Fig. 1. Scale Values and Groupings of Arousal Words into High, Medium, and Low Categories

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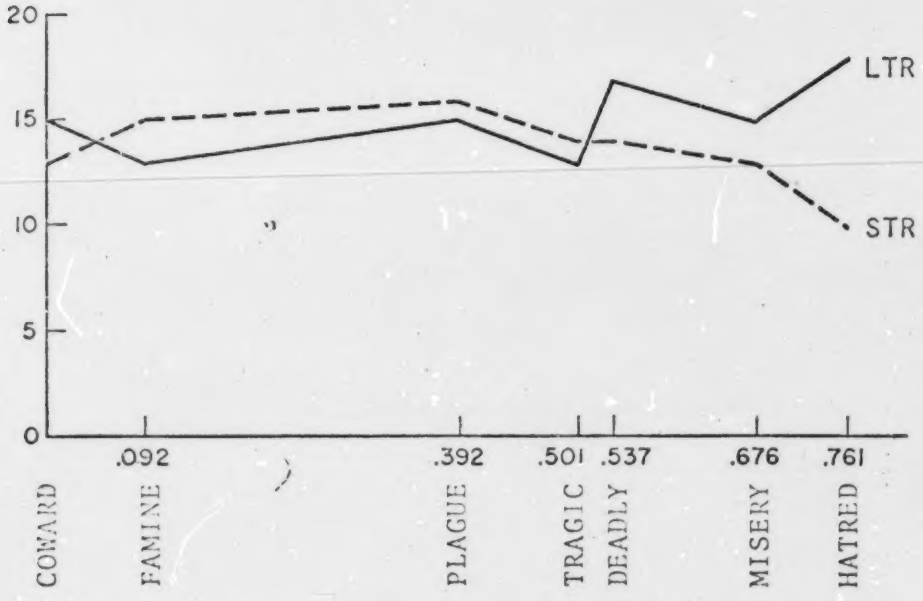

Fig. 2. Frequency of Recall of Words Related to Scale Values of Each Word for STR and LTR

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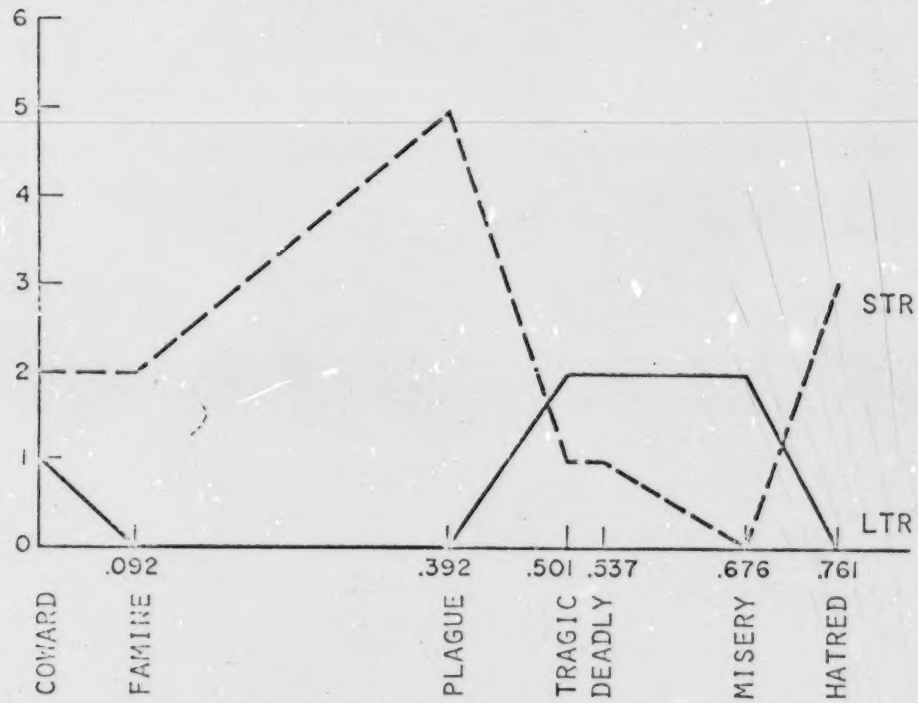

Fig. 3. Frequency of Recall of R Digits Related to Scale Values of Each Word for STR and LTR for cued recall condition

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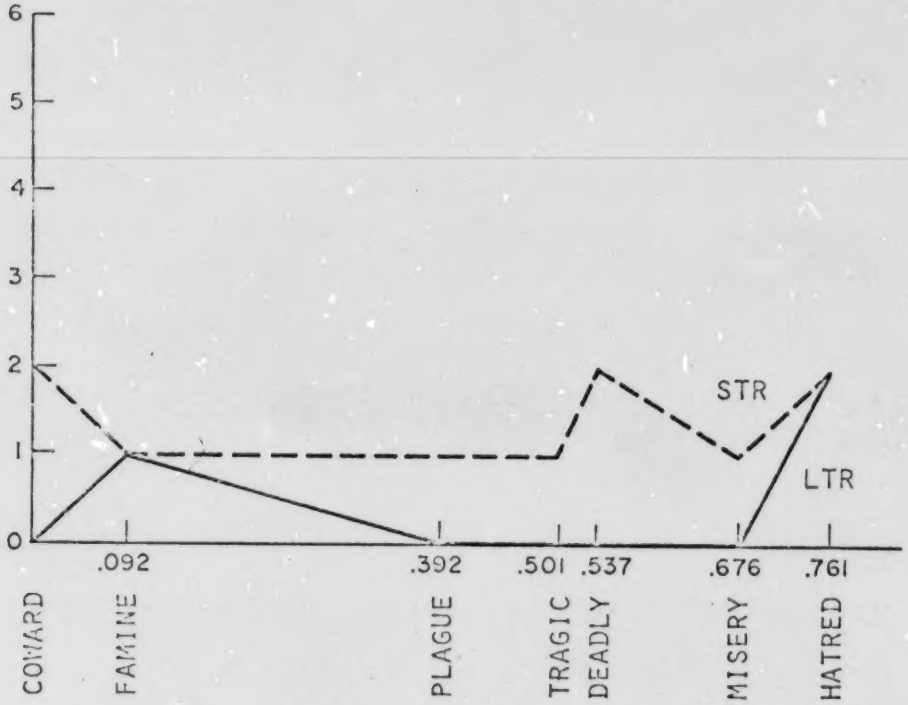

Fig. 4. Frequency of Recall of S-R Pairs Related to Scale Values of Each Word for STR and LTR for Free Recall Condition

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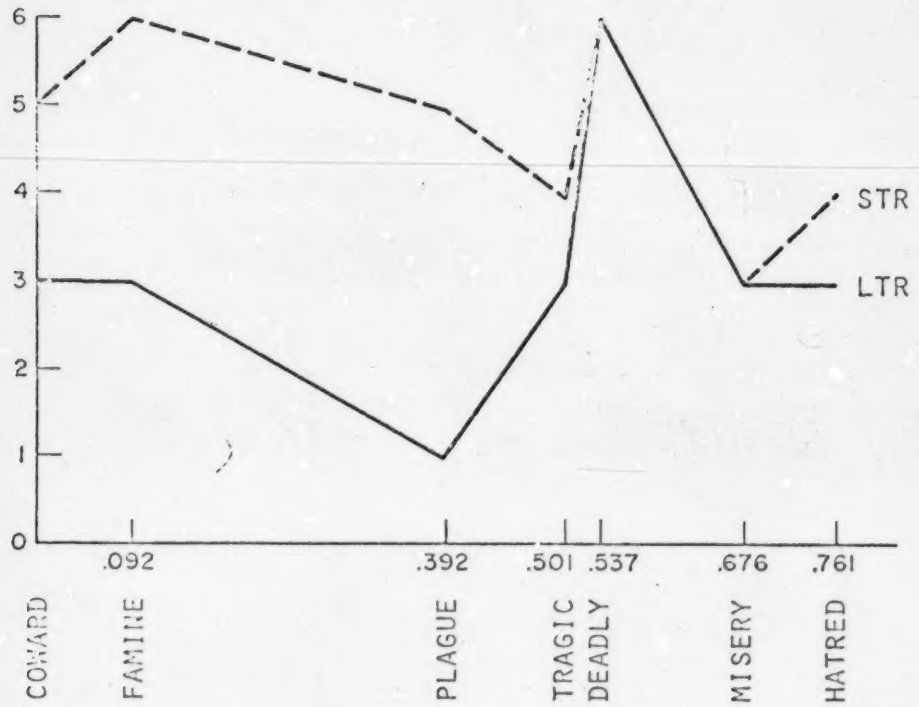

Fig. 5. Frequency of Recall of S Words Related to Scale Values of Each Word for STR and LTR

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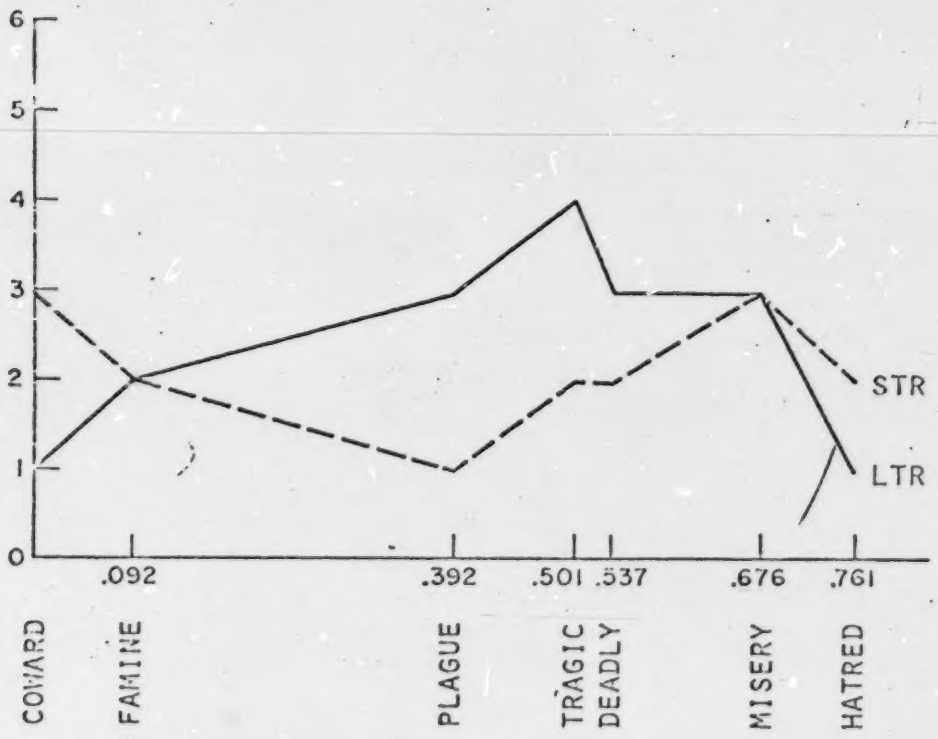

Fig. 6. Frequency of Recall of R Digits Related to Scale Values of Each Word for STR and LTR

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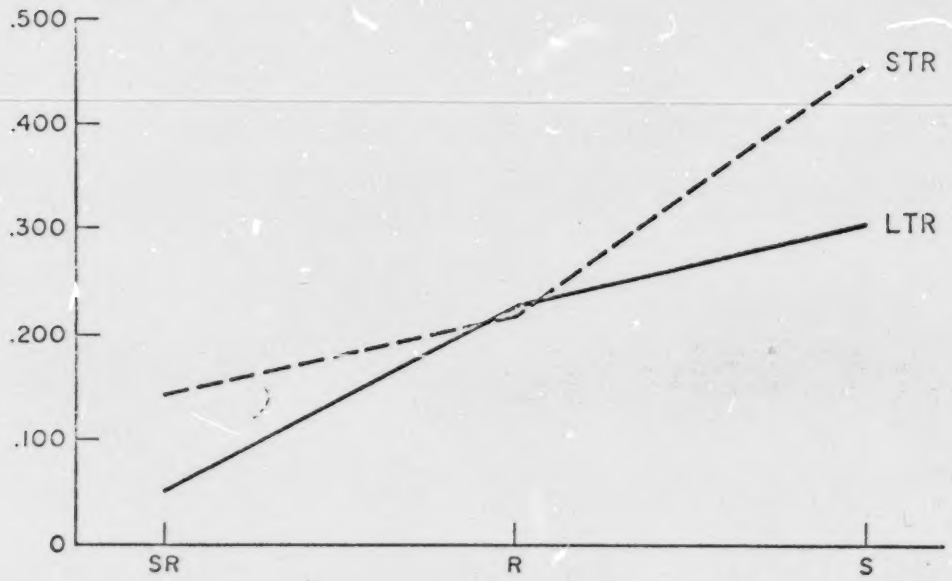

Fig. 7. Mean Proportions of Recall of S-R, R, and S Terms for STR and LTR

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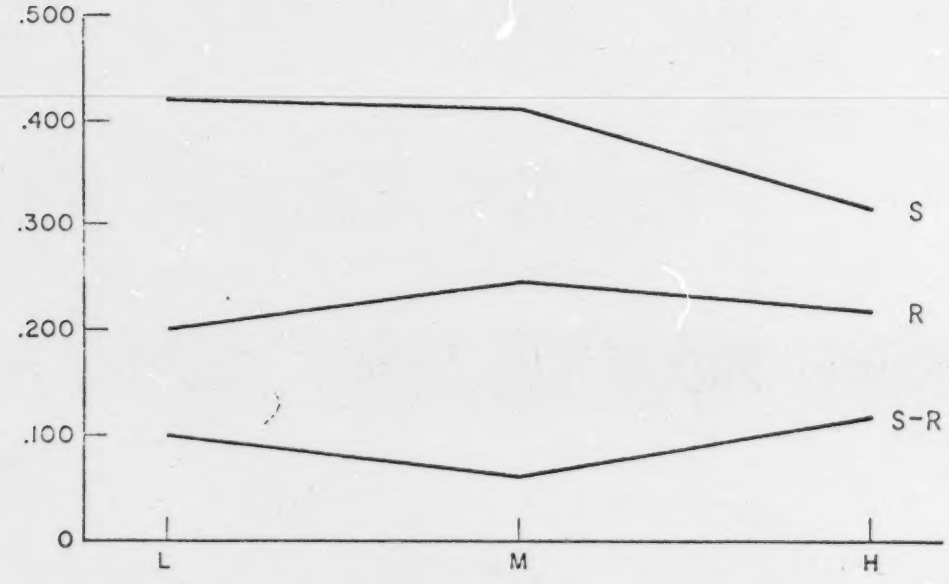

Fig. 8. Mean Proportions of Recall of S-R, R, and S Terms in Relation to Arousal (L, M, and H)

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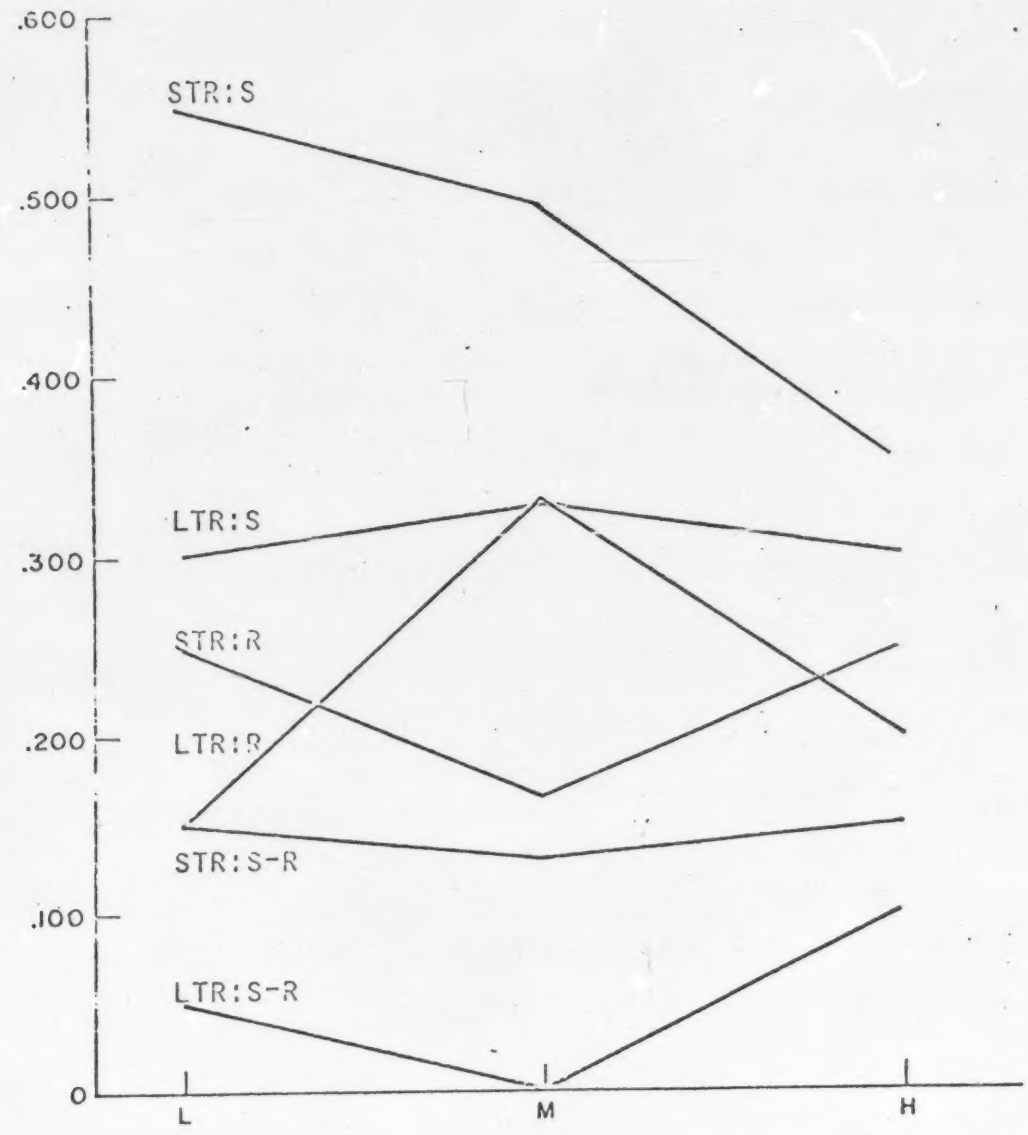

Fig. 9. Mean Proportions of Recall of S-R, R, and S Terms in Relation to Arousal (L, M, and H) under STR and LTR Conditions